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Critical level of Crosstalk for Visual Perception of 3D

Kenji Nakao

Toshiba Mobile Display Co., Ltd., 26-2 Yamadasende, Kawakita, Nomi, Ishikawa, 923-1296, Japan
Tel: +81-76-277-2919

ABSTRACT

Stereoscopic viewing space in which 3D image can be seen in whole display area is very important parameter in mobile 3D displays. In this paper, we discuss critical level of the crosstalk for visual perception of 3D in two-view 3D-display using pattern matching method.

1. INTRODUCTION

Several types of glasses-less 3D display have been proposed such as the parallax barrier type, the lenticular lens type, and the scan backlight type. Some users who are not familiar with 3D displays are sometimes puzzled to get 3D perception. It is important for mobile-use 3D display to keep wide viewing space in which 3D image can be seen in whole display area. Especially for touch panel operation, shorter 3D viewing distance is also desired.

Viewing space for visual perception of 3D has been discussed in many papers as QVS (Qualified Viewing Space). Taira et al. proposed QSVS (Qualified Stereoscopic Viewing Space) conceptually to indicate viewing space of acceptable 3D level in whole panel. And the paper suggested that its key item is 3D-crosstalk[1]. Horikoshi et al. proposed "Interocular 3D Purity" and show some viewing space mapping of experimental results of some 3D displays[2][3]. However, critical condition of crosstalk for 3D perception has not been reported in detail. We have developed some scan backlight type 3D displays using directional backlights and reported 3D-quality mapping of them [4,5].

In this paper, critical level of crosstalk for visual perception of 3D will be cleared.

2. EXPERIMENTAL

We will discuss a case of displaying test images shown in figure 1 (L,R) in ideal 3D display. It include whole combination of crosstalk between the left and the right image. In the image for right eye (figure 1 (R)), crosstalk vary horizontally from the left side to the right side. At the left side crosstalk is 0%, correct image, and at the right side that is 100%, incorrect image. Similarly, in that for left eye(figure 1 (L)), crosstalk vary vertically from the top to the bottom end.

In this paper, crosstalk is defined by following equation. The parameter mean ratio of incorrect light to total light.

$CT_{WB}=(L_{BW}-L_{BB})/(L_{WW}-L_{BB})$

Here, CT_{WB} is crosstalk in which display for left eye is "white" and that for right one is "black". L_{**}, (L_{WW}, L_{BB}, L_{WB}, L_{BW}), are the luminance for each image, and "*" are defined as "white" or "black" and the former is for left eye and latter is for right eye. Using this definition, crosstalk vary from 0% to 100%, and 0% mean a case of pure correct image, and 100% mean that of pure incorrect image.

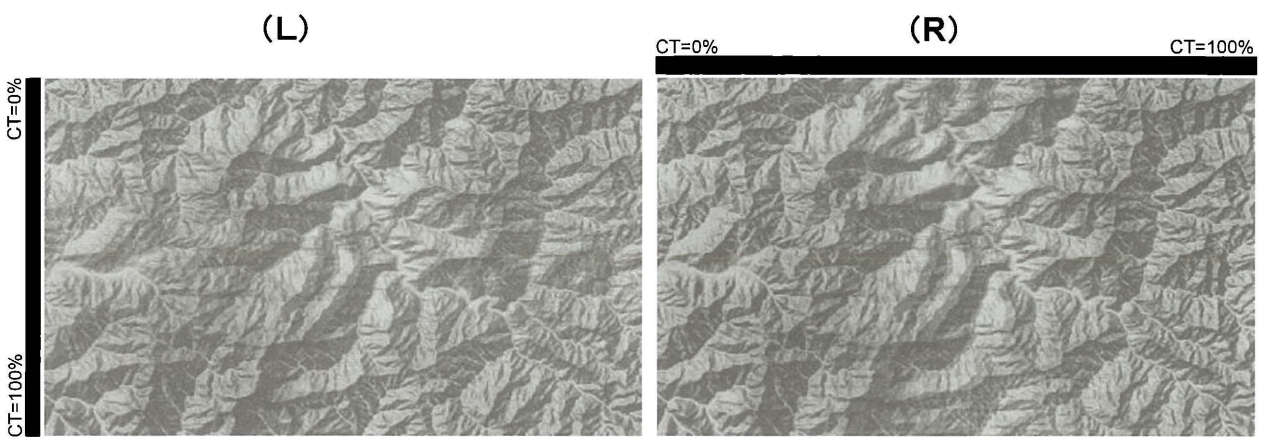


Figure 1 Test images to categorize 3D conditions

3. Results

In this 3D image, it can be seen three types "3D", "2D" and "invert parallax" and their boundary are critical. In "3D" area, the mountain is seen as mountain. In "invert parallax" area, it is seen as valley, and in "2D" area, it is seen as plane picture. It is drawn as figure 2. At the left-top corner of the 3D image, it is seen as "3D" perception because correct images are shown in both eyes. At the opposite right-bottom corner, it is seen as "invert parallax" because of incorrect images in both eyes. On the line from right-top corner to the left-bottom corner, it is seen as "2D" because right and left image are same. We have an interest in boundary condition or critical level of crosstalk. In this result the 3D area is wider than I expected. If crosstalk is 0% in the left or the right image, the other crosstalk can be allowed until 50% for 3D perception. If crosstalk values of both left and right are same, it is allowed until about 33%.

These boundary condition are explained as following pattern matching method. Existence of crosstalk means that incorrect image is mixed in correct image. There are two images which are separated by parallax distance in each images for left and right eye. When the patterns of the left and right image are overlapped, there are three ways of matching. And their parallax distance of the three types are related to the each viewing type. Both correct images of each eye are matched for 3D perception. When Correct image and incorrect image are matched, there is no parallax distance and the perception is 2D. Both incorrect images of each eye are matched for invert parallax. In the 3D or the invert parallax case there are two ghost image located on both side of the correct image. Human brain has chosen the best matching case from the three types and perceived "3D", "2D" or "invert parallax".

To analyze numerically, it is explain as follows. Correct components of Left and Right image in luminance are

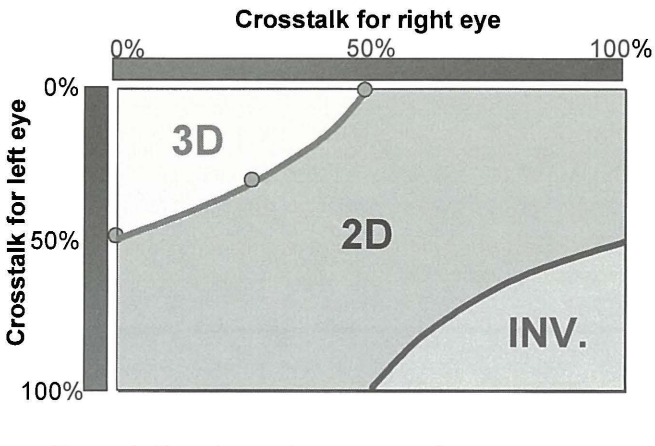
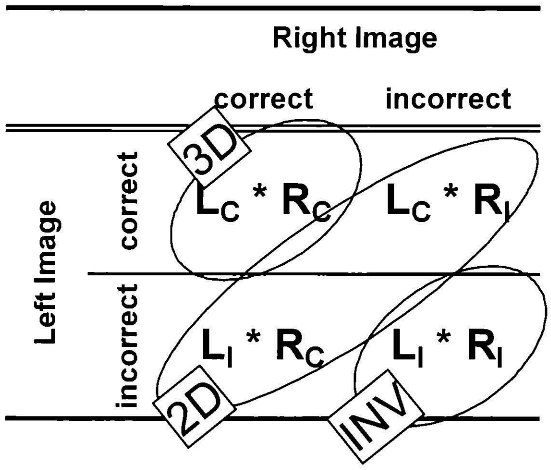


Figure 2 Experimental perception of the test images

Table 1 Categorizing method and discrimination matrix

$$\max\begin{cases}\text{(A) 3D} : L_C * R_C \\ \text{(B) 2D} : L_C * R_I + L_I * R_C \\ \text{(C) Inv} : L_I * R_I\end{cases}$$



defined as L_C and R_C respectively, and similarly incorrect components are L_I and R_I.

$L_C = (L_{WB}-L_{BB})/ (L_{WW}-L_{BB})$
$L_I = (L_{BW}-L_{BB})/ (L_{WW}-L_{BB})$
$R_C = (L_{BW}-L_{BB})/ (L_{WW}-L_{BB})$
$R_I = (L_{WB}-L_{BB})/ (L_{WW}-L_{BB})$

A two by two matrix array is made from products of two parameters. In this paper, we propose a method to categorize perception from these value. The matching values M of 3D, 2D or Invert are described as $M_{3D}=L_C*R_C$, $M_{2D}=L_I*R_C+L_C*R_I$, $M_{inv}=L_I*R_I$. Maximum of these three M value is correspond to the perception. The calculation results of the test images shows good agreement with experimental results in figure 2. The condition for visual perception of 3D is that the M_{3D} is maximum of the three M parameters.

4. SUMMARY

We proposed a new method to categorize 3D, 2D or Invert parallax and clear the critical condition of crosstalk for visual perception of 3D. The method is useful to mapping the Stereoscopic Viewing Space.

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